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Using knowledge management to innovate U.S. Coast Guard Command Center Processes

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THESIS

USING KNOWLEDGE MANAGEMENT TO INNOVATE U.S. COAST GUARD COMMAND CENTER PROCESSES

by

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June 2001

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The U.S. Coast Guard (USCG) responds to thousands of alerts received each year from the Search and Rescue Satellite-Aided Tracking (SARSAT) system. Each alert requires an efficient and effective response to assist a potential mariner in distress. This thesis provides an in-depth analysis of the process employed by USCG Command Centers in responding to SARSAT alerts. The purpose of this analysis is to identify alternatives that can improve the knowledge work performed in the process. This thesis builds on recent work that focuses on knowledge management and system design from three integrated perspectives: 1) reengineering, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. The integrated framework covers the gamut of design considerations from the enterprise process at large, through alternative classes of knowledge in the middle, and on to specific systems in detail. The SARSAT response process is examined using this integrated framework and identifies five technological and organizational alternatives that offer significant potential to improve the overall performance of the process.

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USING KNOWLEDGE MANAGEMENT TO INNOVATE U.S. COAST GUARD COMMAND CENTER PROCESSES

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ABSTRACT

The U.S. Coast Guard (USCG) responds to thousands of alerts received each year from the Search and Rescue Satellite-Aided Tracking (SARSAT) system. Each alert requires an efficient and effective response to assist a potential mariner in distress. This thesis provides an in-depth analysis of the process employed by USCG Command Centers in responding to SARSAT alerts. The purpose of this analysis is to identify alternatives that can improve the knowledge work performed in the process. This thesis builds on recent work that focuses on knowledge management and system design from three integrated perspectives: 1) reengineering, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. The integrated framework covers the gamut of design considerations from the enterprise process at large, through alternative classes of knowledge in the middle, and on to specific systems in detail. The SARSAT response process is examined using this integrated framework and identifies five technological and organizational alternatives that offer significant potential to improve the overall performance of the process.

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I. INTRODUCTION

A. PURPOSE

This research examines Coast Guard command center processes to identify knowledge management organizational, and technological innovations. Processes are examined using current research methods that draw from business processing reengineering, expert systems development, and information systems analysis and design. This integrative framework approach provides a unique coherent knowledge management design methodology.

B. BACKGROUND

Today, the U.S. Coast Guard is a multi-mission maritime service that has responsibilities in five mission areas (USCG 1999):

1. Maritime Safety.
2. Protection of Natural Resources.
3. Maritime Mobility.
4. Maritime Security.
5. National Defense.

Coast Guard Command Centers located throughout the United States are responsible for providing operational oversight and support for the missions that occur within their area of responsibility. However, it is the Maritime Safety mission that often requires the most resources and efforts to be allotted by command centers. Particularly, the actions taken to respond to alerts generated by the Search and Rescue Satellite-Aided Tracking System (SARSAT). This system delivers electronic alerts from mariners who may be in a distress situation. Each alert is unique and requires careful analysis to identify the appropriate response given the current circumstances. Coast Guard

Command Centers often direct an air or surface asset to investigate the alert position and provide assistance as necessary. Generally speaking, the process is performed well. However, some of the process steps are performed using manual methods and others require coordination between different organizational levels that can lead to inefficiencies in the overall process performance.

This research takes a knowledge management (KM) approach to identify alternatives that offer significant potential to improve the SARSAT response process. Process tasks targeted for improvement are: more efficient analysis of alert messages, faster response decisions, and improved knowledge transfer/retention. A KM approach is used since it adopts a comprehensive examination of the people, process, and technology used by an organization that other management disciplines may not fully consider. Additionally, the SARSAT process is representative of the type of knowledge work performed by a command center (CC), offering potential for innovations to be leveraged in other CC processes.

Specifically, this thesis draws from current research that employs an integrated approach to knowledge management and system design (Nissen et al. 2000). This integrated approach also uses a redesign tool that automates key intellectual activities required for SARSAT process analysis. The automated redesign tool provides an objective examination, and increased process analysis efficiency, compared to manual methods.

C. KNOWLEDGE AS AN ORGANIZATIONAL RESOURCE

Knowledge management has emerged in recent years as a management discipline increasingly being adopted by the public and private sectors. In many cases, it has

supplanted other initiatives, such as the total quality movement and business process reengineering. These other initiatives flourished during the early 1990's, but have now become relatively ineffective in today's economy. The management community has come to realize that competitive advantage lies in what an organization and its employees know, which is at the heart of how well an organization functions (Davenport and Prusak 1998). A driving force toward this trend has been emergence of the global economy that has fueled narrow profit margins, causing firms to seek out new methods to innovate and remain competitive. If properly designed and implemented, information technology has been shown to be a KM enabler, especially after the past decade of exponential growth in technology capabilities (e.g. processing power, disk storage, and applications).

The rationale used by the public sector to adopt a knowledge management approach is also applicable to the military services. A key issue that the military has always grappled with is a high job turnover rate, due to yearly job transfers, separations and retirements. This has led the services, including the Coast Guard, to establish the roles of chief information/knowledge officers (CIO/CKO) and to pursue knowledge-management interventions of their own. However, given the lack of experience possessed by the Coast Guard and other services in this area, research is required to understand how such interventions can be applied effectively.

D. RESEARCH QUESTIONS

This research focuses on answering the following questions:

1. Primary Research Question

How can knowledge management interventions, both organizational and technological, be applied to innovate work processes performed in a Coast Guard Command Center?

2. Secondary Research Questions:

a. How is knowledge management used for process innovation in the military and industry?

b. What processes are associated with Coast Guard command centers, and how are they currently performed?

c. What problems or shortcomings can be identified with command center processes?

d. How can knowledge management interventions be applied to innovate command center processes?

e. How should such processes be migrated from their current configuration to effect knowledge management innovations?

f. How can the results of this study be generalized to other organizations and processes?

E. SCOPE OF THESIS

This research focuses on examining processes associated with responding to distress alerts received through the Search and Rescue Satellite-Aided Tracking (SARSAT) system. Actions taken for these alerts are representative of the many functions a Coast Guard Command Center performs. It provides ample opportunity to examine the processes, identify interventions (both organizational and technological), and innovate knowledge management within Coast Guard Command Centers.

F. METHODOLOGY

Work for this thesis begins with conducting a literature search of books, journal articles, and credible Internet based sources. This thesis draws from recent research that focuses on knowledge management and system design from three integrated perspectives:

1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. The integrated perspectives provide a unique framework for knowledge process and system design.

Next, the SARSAT alert process is investigated by conducting telephone or in-person interviews with duty officers at Coast Guard District Eleven and District Five Command Centers. Responding to SARSAT alerts is analyzed from three levels (e.g. process, knowledge, and context), which together provide a more complete approach than traditional methods that often focus on just the process.

Using the results of the three-level analysis aids in identifying innovations to automate and support knowledge work within the process.

G. ORGANIZATION OF RESEARCH

The remainder of the thesis is organized into four chapters. Chapter II provides background information on knowledge management and current efforts within the business and military sectors. Chapter III examines the process used by Command Centers in responding to SARSAT alerts. Chapter IV discusses the knowledge and contextual issues associated with SARSAT alerts. It also provides organizational and technological interventions that can innovate knowledge management at Coast Guard Command Centers. Chapter V follows with conclusions and recommendations.

H. BENEFIT OF STUDY

This research identifies process changes that can innovate knowledge management within Coast Guard Command Centers and similar organizations.

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II. KNOWLEDGE MANAGEMENT

A. INTRODUCTION

During the past 50 years, the American economy has undergone a significant transformation from an almost pure production-based value system to an intellectual and skill-based value system. This has placed an ever growing percentage of knowledge value contained within goods and services. Today, knowledge is being considered one of the most important strategic resources for businesses to differentiate themselves from their competitors. As Drucker (1995) writes, "knowledge has become the key economic resource and the dominant—and perhaps even the only—source of comparative advantage."

In the past, knowledge was often taken for granted, and was never explicitly valued or managed. In today's dynamic global economy, none of the old rules apply. Companies must now explicitly address a range of decisions regarding the creation, development, and maintenance of their knowledge resources and capabilities. This has spawned an increasing number of public and private organizations to appoint Chief Knowledge Officers (CKOs) to oversee this valuable resource. To be effective, organizations embracing a knowledge-based perspective need to establish a strategy to fully leverage knowledge resources and capabilities to support their goals and mission.

B. KNOWLEDGE MANAGEMENT DEFINED

Knowledge management can be an elusive topic. Efforts to locate a precise definition for knowledge management result in a myriad of interpretations on what exactly this management discipline encompasses. The following are a few notable definitions:

1. A discipline that "promotes an integrated approach to identifying, capturing, retrieving, sharing, and evaluating an enterprise's information assets. These information assets may include databases, documents, policies, and procedures, as well as the uncaptured tacit expertise and experience stored in individual workers' heads." (Gartner Group, 1999)

2. "A process for optimizing the effective application of intellectual capital to achieve organization objectives." (CIO, Department of Navy, 2000)

3. "Is getting the right information to the right people at the right time so they can make the best decisions." (Gordon Petrash, Dow Chemical, 1996)

4. "Is a systematic, explicit, and deliberate building, renewal, and application of knowledge to maximize an enterprise's knowledge-related effectiveness and returns from its knowledge assets." (Carl Wiig, 1997)

From these definitions we can interpret that knowledge management, as a discipline, treats intellectual capital as a managed asset, which *can* be leveraged by information technology (IT).

The primary components (Hackett 1998) applied in knowledge management are people, processes, and technology. These components of knowledge management must be uniquely balanced to obtain improved performance and productivity (DOD 2000). As Ruggles (1998) proposes, a 50/25/25 balance of resources (people, processes and technology) is essential from the outset. However an organization must be mindful when deploying IT to consider the organizational dynamics and process(es) involved. Blindly employing IT will most likely fail to reap the benefits it was intended to provide.

Looking at knowledge more closely shows that it has its roots in three primary areas (Fauntleroy and Klein 2000), which must be considered when developing a knowledge-management solution:

1. *Data*: A set of discrete, objective facts about events or functional processes. It does not provide any inherent meaning, importance, or relevance. It just describes a part of what happened.
2. *Information*: Consists of facts and data that are organized into a meaningful context to describe a particular situation or condition.
3. *Knowledge*: Consists of ideas, values, insight and judgments of individuals. It is dynamic and can only be accessed from experts through direct collaboration and communication.

These three components represent the knowledge assets an organization must manage in order to ensure a dynamic, innovative and agile organization. Typically, organizations become focused on the lower two assets (particularly data) and employ databases to store large quantities of data, which by themselves, do not contribute to organizational knowledge. Only when data is coupled with structure, meaning, and relevance does it transform into useable information. Continuing with this evolution requires information to be augmented with context, reasoning and understanding to foster knowledge creation.

Knowledge can take many forms, but in the literature, it is usually split into two general categories:

1. *Explicit*: What has been written or otherwise recorded. It includes knowledge being codified through books, manuals, databases, reports, policies, and procedures. This knowledge can therefore be readily identified, articulated, captured, shared, and applied.
2. *Tacit*: The expertise and wisdom contained within people's heads making it highly personal. Often, it takes the form of a mental model containing beliefs, intuition, and perspectives that may be taken for granted by the holder.

Tacit knowledge can be extremely difficult to codify, compared to explicit knowledge, because the holder's knowledge is so ingrained (e.g. the craft of cabinetry), which makes it difficult to articulate and transfer from one individual to another. Therefore, much of the emphasis has been focused on developing information technology

(IT) systems that codify explicit knowledge (e.g. groupware, intranets, books of knowledge) because they are easier to develop. Capturing tacit knowledge with a IT system is much harder (e.g. expert systems) because it requires significant efforts before a system attains the ability to duplicate human capabilities.

C. BUILDING A LEARNING ORGANIZATION

If organizations are going to continue to prosper in an ever changing environment, then it is essential that they make a commitment to learning. Many organizations are struggling today because they do not adapt quickly enough to respond to their rapidly changing markets. As Garvin writes (1993), "in the absence of learning, companies and individuals simply repeat old practices. Change remains cosmetic, and improvements are either fortuitous or short-lived."

A learning organization can be hindered in its development if it has what Senge (1990) calls learning disabilities:

1. "*I am my position*" - People within an organization become so focused on their job that they lose sight of the big picture and do not understand how their efforts contribute to the organization.
2. "*The enemy is out there*" - When things go wrong, there is a propensity for people to seek out someone or something to place blame.
3. "*The illusion of taking charge*" - Someone attempts to quickly tackle tough problems head-on before they get out of hand. However, the manner in addressing the problem is flawed or ill-conceived. The effort then becomes a reactive measure that will likely not produce the best outcome.
4. "*The fixation on events*" - Focusing on the event leads to "event" explanations which are narrow in scope. Learning occurs when emphasis is placed on seeing the long-term patterns of change on what *caused* the events.
5. "*The parable of the boiled frog*" - Boiling a frog occurs only if the temperature is raised slowly. Otherwise it jumps out of the pot. Likewise, being able to see *slow* gradual change (not just dramatic) is crucial, as in

the case of American automakers' reluctance to build fuel efficient cars in the early 1970's.

6. "*The delusion of learning from experience*" – Some decisions (e.g. R&D efforts, promotion of people) provide the least opportunity for trial and error. Cycles are hard to observe since they occur years later. This leads to an over abundance of bureaucratic functional divisions created as an attempt to better cope with decisions. The result: analyzing cross-functional problems and issues becomes impossible or difficult to perform.

7. "*The myth of the management team*" – Often teams spend considerable time fighting for "turf." To maintain a positive image, they squelch disagreement. People with serious reservations do not state them publicly, and joint decisions are watered-down compromises. These teams may perform routine tasks well, but under pressure, they will likely break down.

By mitigating the "disabilities," an organization will then be able to leverage Senge's five disciplines toward building a learning organization. The first two disciplines are applicable to a group or team. The remaining three are aimed at the individual. The five disciplines are:

1. Team Learning – People must suspend their assumptions and freely think together. That involves engaging in unfettered group dialogue to discover insights not attainable individually. It also involves identifying team interaction patterns that may hinder learning.

2. Building Shared Vision – If organizations bind people around a genuine vision and sense of destiny, their people will become motivated. The common bond will trigger an inner drive for their people to excel, learn, and contribute.

3. Mental Models – These are deeply ingrained assumptions or beliefs that influence how one behaves or understands the world. Often these models work subconsciously within individuals. Organizations must unearth these models and scrutinize them. They must each be validated to reflect shared models of the organization, their market, and their competitors.

4. Personal Mastery – This goes beyond competence and skills. On a personal basis it requires continually clarifying what is important and seeing reality more clearly. It means approaching life as a creative work and living it from a creative perspective rather than from a reactive viewpoint. By committing to lifelong learning, one can realize results that matter most to them and collectively help an organization to learn.

5. Systems Thinking – The "fifth discipline" is an ability and practice to consistently examine a situation from a whole system perspective, rather

than focusing on parts, which yield incomplete information. Using this conceptual framework approach reveals full patterns, and also aids understanding in identifying what needs to be done in order to change them most effectively.

Systems thinking holds the distinction of being the "fifth discipline" since it serves as an integrator of all the other disciplines. Each of these components provides what Senge believes is a vital dimension toward building organizations capable of learning and achieving their highest goals.

Garvin (1993) takes a different approach, believing Senge's disciplines are too abstract and do not provide concrete guidance toward building a learning organization. He proposes a foundation consisting of meaning, management, and measurement (the "three Ms") that will serve as a basis for launching a learning organization. The first M, *meaning,* requires organizations to identify a well-grounded definition of a learning organization that is actionable and easy to articulate. Next, *management* requires the organizational leaders to establish firm guidelines that are replete with operational direction rather than lofty aspirations. The final M is *measurement,* where the organization needs to employ better tools for assessing the level of learning to confirm their progress. With a well-established foundation, Garvin (1993) proposes that learning organizations can then become skilled at doing five main activities:

1. Systematic Problem Solving – This focuses on employing a scientific method for diagnosing problems. Simple statistical tools such as histograms and Pareto charts are used to organize the data and draw inferences. Decision making is based on firm data instead of assumptions.
2. Experimentation – This activity involves systematic searching and testing of new knowledge. It usually involves two activities: ongoing programs and one of a kind demonstration projects.
3. Learning from past experience – Organizations need to continually review their past achievements and failures, assess them systematically, and record the lessons in a manner in which employees can easily locate and retrieve.

4. Learning from each others – This involves learning by looking outside one's immediate environment, such as other departments, or even different businesses. Looking outside the organization can be beneficial to break the "group think" mentality and identify unique ideas, perspectives, or foster creative thinking.

5. Transferring knowledge – The organization benefits most when knowledge is shared quickly and efficiently so that everyone has the opportunity learn. Mechanisms to share knowledge include: oral/written reports, site visits and tours, personnel rotations, and training and education programs. All have their strengths and weaknesses, but the methods offering active involvement (e.g. personnel rotation programs) are more effective in terms of transferring knowledge than passive activities (e.g. reading written reports or tours).

Both Senge and Garvin provide interesting perspectives on what should be considered in order to build a learning organization. Of particular interest are Garvin's last three activities and the issues that affect them. They are discussed in the next two sections.

D. INTELLECTUAL CAPITIAL

The ability for an organization to learn is influenced by how well intellectual capital is managed. Learning occurs when different ideas, perceptions, and ways of processing information collide. Hiring and promoting people from the same stripe or background (Leonard and Straus 1997) brings together people that share similar interests, training and thoughts. Due to the common cognitive filters, only familiar ideas survive, and the others that hold potential are lost. To counter this, Leonard and Straus recommend that organizations seek a diverse group of people to fill their positions. The diversity that organizations should seek is to hire qualified individuals with different backgrounds who think and act differently. Bringing the diverse group of people together can lead to developing "creative abrasion" amongst the workers. This intentional combining of people with different skills, values, and ideas can elicit innovation that a

non-diverse workforce might not ever achieve. Additional "best practices" to managing intellect include: recruiting the best people, forcing intense early development of new workers, providing constant challenging work to foster professional growth among workers, and performing frequent performance appraisals (Quinn, Anderson and Finkelstein 1996).

E. TRANSFERRING KNOWLEDGE

A key attribute of a learning organization is becoming adept at transferring newly created knowledge to make it widely available to all potential users within the organization. In today's economy, transferring knowledge can be a challenge due to the higher turnover rate of the workforce. The notion of working for just one employer until retirement has nearly ceased. Economic pressure is even changing Japan's coveted guaranteed lifetime employment model. Now, the changing economy has some people switching jobs every 3.5 years (Labor 2000), and in the high-tech industry, turnover occurs more frequently at around 2.5 yrs or less (ITAA 2001). Job rotation is a primary concern for the military services since personnel are transferred yearly due to assignment completion, retirement or enlistment completion. This can lead to organizational "de-skilling" as knowledge workers leave the organization. Many organizations try to counter this effect by codifying explicit knowledge into procedures, report, memos, and lessons learned. This is a start but an organization must also employ a strategy to transfer knowledge more effectively across time and space. This apparently has been difficult to do as 44% of respondents to a recent Ernest and Young survey (quoted in Brock 2000) reported they were either poor or very poor at transferring knowledge within their organization.

Dixon (2000) has identified five methods to effectively transfer explicit and tacit knowledge. Determining what transfer method to use for a particular situation is done by looking at the following criteria:

1. Who the intended receiver of the knowledge is in terms of similarity in tasks and context.
2. The nature of the tasks in terms of how routine and frequent it is.
3. The type of knowledge that is being transferred.

It is best if the receiver is somewhat familiar with the knowledge that is going to be transferred. If the task and context differ greatly from what the receiver is already familiar with, then they may not have the "absorptive capacity" (Cohen and Levinthal 1990) to effect the transfer. When looking at the nature of the task, one should determine the frequency (e.g. daily, weekly, monthly), the steps that are employed, and whether the task is routine or non-routine. The type of knowledge being transferred (explicit vs. tacit) and where within the organization the transfer will have an effect, determine what method works best. Table 1 summarizes each of the transfer systems and provides an example of when a particular system should be used.

Leading practices currently being employed to transfer knowledge are through the use of After Action Reports (AARs), "lessons learned" or "learning histories." Table 1 shows these methods would be employed during the serial, near and strategic transfer systems.

The U.S Army is often credited with pioneering the use of AARs. Although many companies may have already been doing similar reporting, the Army takes a unique approach. After an event, participants meet to discuss the following (Dixon 2000):

1. What was supposed to happen?
2. What actually happened?
3. What accounts for the difference?

	Serial Transfer	Near Transfer	Far Transfer	Strategic Transfer	Expert Transfer
Definition	The knowledge a team has gained from doing its task in one setting is transferred to the next task in a different setting.	Explicit knowledge a team has gained from doing a frequent and repeated task is reused by other teams doing very similar work.	Tacit knowledge a team has gained from doing a nonroutine task is made available to other teams doing similar work in another part of the organization	The collective knowledge of the organization is needed to accomplish a strategic task that occurs infrequently but is critical to the whole organization.	A team facing a technical question beyond the scope of its own knowledge seeks the expertise of others in the organization
Similarity of task and context	The receiving team (which can also be the source team) does a similar task in a new context	The receiving team does a task similar to that of the source team and in a similar context	The receiving team does a task similar to that of the source team but in a different context.	The receiving team does a task that impacts the whole organization in a context different from that of the source team.	The receiving team does a different task from that of the source team, but in a similar context.
Nature of the task	Frequent and nonroutine	Frequent and routine	Frequent and nonroutine	Infrequent and nonroutine	Infrequent and routine
Type of knowledge	Tacit and Explicit	Explicit	Tacit	Tacit and explicit	Explicit
Example	A power generator re-placement team replaces a generator in a chemical plant. The team uses that knowledge when replacing a generator in a refinery.	A team in an Atlanta auto plant figures out how to install brakes in ten seconds. A team in Chicago use that knowledge to reduce its time by fifteen seconds.	Peers travel to assist a team dealing with a unique oil exploration site. The collaboration provides new approaches.	A company acquires ABC; six months later another team in different location uses what was learned with ABC to acquire DFG.	A technician e-mails the network asking how to increase the brightness on out of date monitors. Seven experts provide answers.

Table 1. Common Knowledge Transfer Systems (After Dixon 2000).

The military culture might lead some participants to feel that they could not truly speak freely. The Army quickly mitigated this issue by establishing a ground rule that people can speak openly, and anything said during an AAR cannot be used in any kind of personnel action. Naturally, any organization adopting this ground rule will need time to demonstrate commitment to it in order to gain trust from its people; which the Army has done. Often, no written record is kept of an AAR, but notes may be kept for local use. In special circumstances where the service as a whole could benefit, these notes are sent directly to the Center for Army Lessons Learned (CALL). The key to performing these AARs is to hold them as soon as possible after the event. Otherwise, one's recollections

of important facts tend to diminish as time increases. After Action Reports can be more effective than Lessons Learned because the latter is often a report providing the author's (or a limited few) perspective. It also lacks the AAR group dynamics that can elicit more responses.

In the commercial sector, AARs have been adopted at motorcycle producer Harley Davison (Graham 2001). However, they have made one change well-suited to a production or assembly environment that further improves the value of an AAR. Rather than wait until after production to identify best practices, they perform a limited test production followed by an immediate AAR. This approach allows them to identify and incorporate those leading practices into the production cycle to garner immediate benefit, rather than record them for *possible* use later.

Another approach called "learning histories" (Keiner and Roth 1997) can be viewed as a hybrid between AARs and Lessons Learned (LL). Learning histories are used to summarize a major event or episode just like AARs or LL. They differ in that interspersed throughout the report are comments. A break in a paragraph is made and two columns are inserted for these comments. The right-hand column contains participants' recollections and those comments are identified only by job position title to provide some anonymity and foster frank discussion. The left column contains analysis and commentary by qualified outsiders. The role of the external analysis is to sort through the right-hand column comments to identify recurring themes, pose questions about assumptions and implications, and draw-out any issues not discussed that appear to hover just below the surface of a participant's comments. After completion, the learning history is used for group discussions with those involved and others who might benefit.

Culture is often defined as key to having an effective knowledge transfer within in an organization. It can be defined as the beliefs, values, norms, and behaviors that are unique to the organization. Developing a knowledge-sharing culture (Hackett 2000) relies on the following principles:

1. Shared vision.
2. Value-based leadership at all levels.
3. Open and continuous communications.
4. Rewards and recognitions.

A survey of 431 organizations (Ruggles 1998) identified culture and top management's failure to signal the significance of sharing knowledge as the biggest impediments to knowledge transfer.

Maintaining open and continuous communication, through formal and informal means, is equally important. Informal mechanisms can often be a richer source of knowledge than what is provided by formal means (Weick 1995). However, informal methods are most effective when the organizational culture has established the appropriate "marketplace" (Davenport and Prusak 1998) to support knowledge sharing. Many Japanese firms, such as Dai-Ichi Pharmaceuticals (Davenport and Prusak 1998), have established unstructured "talk rooms" where researchers meet with colleagues to discuss whatever they choose for approximately 20 minutes a day. In American companies, these informal gatherings usually occur around the water-cooler, at company picnics, or after-work at a local establishment. These random discussions are helpful to stimulate creative thinking and share knowledge that a formal discussion might not elicit.

Calling the transfer system a knowledge management initiative may inadvertently lead to lost support among the workers who may view it as just another management fad

that will pass in time. Employees can also be sensitive to names such as "lessons learned" and "best practices" (Dixon 2000). The former may be interpreted as just a repository for past failures, and workers will usually shy away from a system to avoid putting themselves on report. Using the term "best" can be problematic when potential contributors do not participate because they feel their submission is not good enough. A possible way around this dilemma is to use the term "leading practices." This subtle difference in wording can greatly effect how people react to a new system.

People also need to be motivated to participate in the knowledge system after it has been deployed. Management needs to employ suitable motivational techniques to foster support, or it will be of little value to the organization. The motivation must provide real incentives rather than small enticements to get people to participate (Hansen, Nohria and Tierney 1999). One method that people usually respond well to is to include the level of participation and quality of contributions as part of an employee's performance review. Finally, if no politics are involved in a knowledge initiative, then it is likely the organization perceives it holds no significant value (Davenport 1996).

F. EMPLOYING INFORMATION TECHNOLOGY

The dramatic growth in information technology (IT) capabilities, coupled with attractive cost/benefits analysis, have made IT a popular investment option to support knowledge initiatives. Knowledge management technologies can be viewed as providing a supportive or performative role (Nissen et al. 2000). Most technologies fall within the supportive role where knowledge is organized, formalized and distributed. However, very few systems are capable of the more difficult performative role where knowledge is

created, applied and evolved. The table below is a list of common KM technologies that have been adopted by knowledge intensive organizations (Liebowitz 1999):

KM Technology	Adoption
E-mail	100%
Internet	100%
Video-Conferencing	100%
Project Mgmt Systems	91%
Groupware	91%
Intranet	82%
Knowledge-Based System	82%
Customer Mgmt System	73%
Skill Inventory System	64%
Yellow Pages for Knowledge	44%

Table 2. Knowledge Management Technology Adoption (From Liebowitz 2000).

Electronic mail (E-mail) is an extremely popular tool used by organizations to communicate and also foster collaboration and knowledge sharing. Microsoft's E-mail program Outlook,® has become the de facto standard, which anyone with minimal "Windows" experience can use effectively. The downside of E-mail is that one can become easily overwhelmed with messages from known and unknown senders.

The Internet original began as a late 1960's U.S. government research project and grew into the world's largest computer network serving universities, academic researchers, commercial interests and government agencies worldwide. This vast network serves as a communications backbone for users to immediately exchange data, audio, and/or video.

Video-conferencing enables collaboration between users located at two or more different locations. Each location is configured to display a visual presentation of the other remote participant locations. The visual experience that participants take away from a video-conference helps forge stronger, more productive and meaningful ties

between participants who have previously met in-person. Davenport and Prusak (1998) state that videoconferencing helps to maintain a sense of trust and direct personal contact that far exceeds that of phone calls, email and memos.

Project Management Systems provide users with a centralized view of project related information, such as budget, status, documents, deliverables, meeting minutes and tasks. This results in less project management overhead, so managers can devote more time to decision-making and solving problems, and less time to managing day-to-day project details. Users become more focused and informed, allowing them to see the big picture, while working on their individual tasks. Another benefit is that the systems can enhance project communication among members. Microsoft® Project is one product that can perform this function well.

Groupware is a broad term to denote computer software that support groups of people engaged in a common task It provides an interface to a shared environment. The technology may be used to foster collaboration, coordination, and information sharing between groups of people. "Lotus Notes" is often credited as the first groupware and claims to have attracted millions of users. It is now facing stiff competition from Microsoft® products such as Exchange and Outlook® 2000 (Ruber and Sherman 2000).

An intranet can be viewed as a limited access Internet developed for in-house use within an organization. Often sensitive or proprietary information is offered through databases, shared folders and documents. Users within an organization can still access sites on the Internet, but special equipment (e.g., firewall) is usually employed to function as a filter for keeping outsiders from gaining access into a firm's intranet.

Knowledge-based systems (KBSs) are computer programs (e.g., decision support systems, expert systems) that embody a substantial amount of knowledge about a topic. These systems use the knowledge to mimic the manner in which humans perform a task in an attempt to duplicate "expert" performance (Playle and Beckman 1996). This is achieved by programming the KBS with rules dictating how to apply the knowledge, allowing repeatable reapplication of the knowledge to problems. KBSs facilitate organizations capturing knowledge and expertise that is volatile, subject to loss due to personnel turnover or forgetfulness. However, KBSs have a finite capability and can easily fail or produce erroneous results if the user moves outside the knowledge domain. Capturing the knowledge can also be difficult and tedious, requiring extensive human intervention. And, the KBS can become outdated if it does not have a learning capability.

Customer management systems are often employed to strengthen customer relationships by automating important functions. This can result in gaining a competitive advantage through increased customer satisfaction, higher productivity, and lower costs. Popular systems include Remedy® Customer Support and Primus® eSupport.

Skill inventory systems are online databases that contain information on who, within an organization, holds proficiency in a particular skill. The military services have a long history of employing these types of systems to track personnel with specific skill qualification codes (e.g., C130 engine mechanic, computer system administrator, etc). However, access to data held by these systems is normally restricted to the Assignment Officers located in the personnel departments.

A yellow pages directory for knowledge is similar to skill inventory except it takes a broader approach on identifying personnel who have knowledge or understanding

of a particular subject. Users of the yellow paging system can then identify the person within the organization to assist in problem solving and/or decision-making. Research indicates that large centralized databases tend to be underutilized compared to smaller distributed systems developed for local organizational use. Information is more relevant, current, and has a higher success rate of bringing people together, compared to the centralized system approach (Hackett, 2000).

It is often repeated in the literature that employing technology by cost/benefit analysis alone is not adequate to identify system suitability and will likely fail to produce the desired results (Keil and Markus 1994). Failed knowledge management initiatives often occur due to the temptation to focus efforts on more tangible aspects such as IT and pay less attention to people and work processes the IT will support.

G. KNOWLEDGE MANAGEMENT AND SYSTEM DESIGN

Today, the successful organizations are the ones that view knowledge work from a process perspective (Davenport et al. 1996). The process approach allows an in-depth look at how best to structure, sequence, and measure knowledge work in order to achieve the desired results. The key to this approach is employing a methodology that looks not only at the underlying work activities, but also examines the organizational dynamics associated with the process. The resulting analysis can then be used to design information technology systems to best support or enable knowledge work.

Recent literature (Nissen, Kamel, Sengupta 2000), shows how three complementary design methods can be integrated to address knowledge management. These design methods are drawn from the fields of business processing reengineering (BPR), expert systems (ES) development, and information systems (IS) analysis and

design. Collectively they play a key role in establishing an integrated knowledge management design methodology. This framework is summarized in Table 3.

Step	Activity
1	Process analysis & (re)design
2	Knowledge analysis & representation
3	Contextual analysis
4	IS analysis & design

Table 3. Integrative Framework Methodology.

Before analysis can begin, an enterprise level process associated with knowledge work must be selected. It is best to select key business processes because they directly support meeting the organizational mission and goals and therefore hold the greatest potential for benefit.

1. Process Analysis

This step evolves examining the process analysis using customary reengineering methods (e.g. Davenport 1993, Hammer and Champy 1993, Harrington 1991) that focus on work-flows termed "horizontal processes." These processes are generally depicted using directed graphs (Figure 1) to show the horizontal progression within a process. Understanding the process and the associated knowledge is necessary before designing supporting information technology systems.

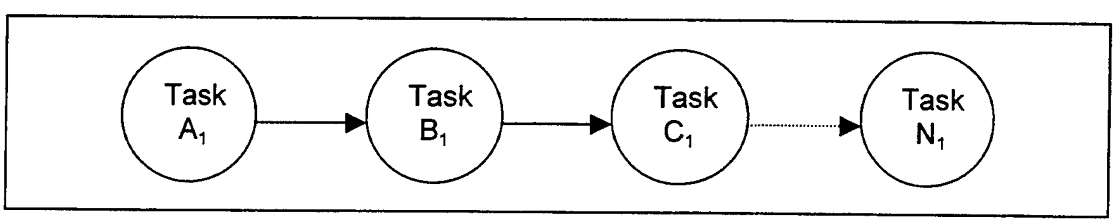

Figure 1. Horizontal Process Analysis.

The analysis may indicate a need for the process to be redesigned. If so, an automated measurement driven redesign method (Nissen 1998) called KOPeR can be employed to identify and treat process pathologies.

2. Knowledge Analysis

The next step is to identify the underlying knowledge required to support the enterprise process. Graphically this can be depicted by extending the horizontal process diagram to reflect its performance through time, space, and across different workers or teams. The extended process representation (Figure 2) also includes vertical processes that interact with the horizontal work flows. While the latter emphasizes performance of the workflow, the vertical cross-process flows are what affect the consistency and efficacy of the enterprise process.

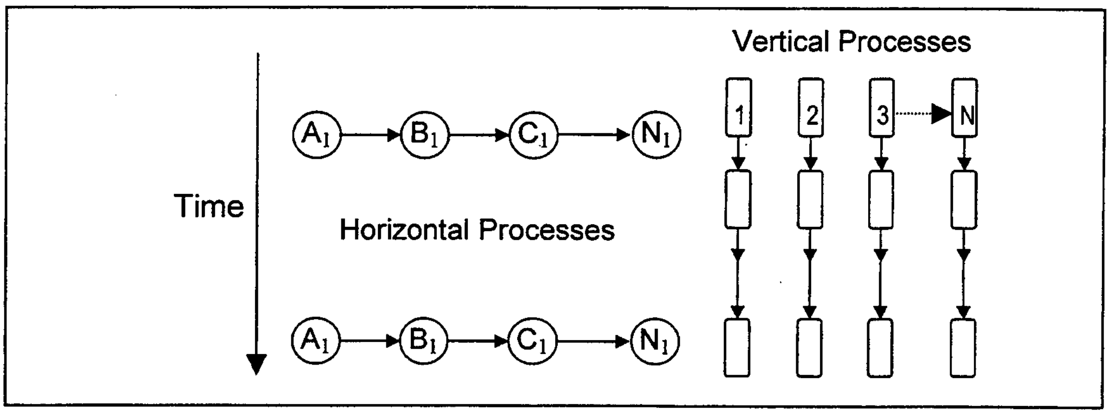

Figure 2. Extended Process Representation (After Nissen, Espino 2000).

Identifying the vertical processes begins by first identifying the organization's overarching goal that the enterprise process is to accomplish. Correctly identifying the desired outcome or goal is essential since it is used to identify the Critical Success Factors (CSFs) that must be achieved for successful accomplishment of the horizontal process. Finally, the CSFs aid in identifying the vertical processes that contain the knowledge required to perform the work by people or different teams throughout the

organization at any time. Therefore, the vertical processes hold significant potential to influence the outcome of the enterprise process and must be analyzed, understood, and possibly even redesigned to best support knowledge management within the organization.

3. Contextual Analysis

The third step of integrated framework requires assessing the contextual factors associated with the enterprise process. Here, an assessment is performed to gain an understanding of the organization and the nature of the knowledge underlying the task. More specifically, an analysis is done to identify how the organizational memory is maintained through formal and informal means. In addition, the assessment looks at how the organization is structured, what knowledge transfer practices are employed, and what incentives are in place to foster retention and updating of knowledge. This analysis is important since the contextual factors also influence how knowledge systems are designed, introduced, and used by an organization.

4. Information System Analysis and Design

Step four incorporates the results from the prior three steps (e.g. process, knowledge, and context) for identifying system requirements to facilitate designing of a system. The new system serves as an enabler for knowledge work, and its true worth hinges on how well the analysis was performed within the integrated framework.

H. KNOWLEDGE-BASED ORGANIZATIONAL PROCESS REDESIGN (KOPeR)

KOPeR (Nissen 1998) is a knowledge based system (KBS) that uses measurement-driven inference for automated process analysis. It incorporates process measures from many fields to include: Artificial Intelligence, Information Systems, Organization Behavior, and Total Quality Management. This wide collection of

measures keeps the tool independent from reengineering-specific methods and increase its robustness. The activities often associated with process redesign are shown below.

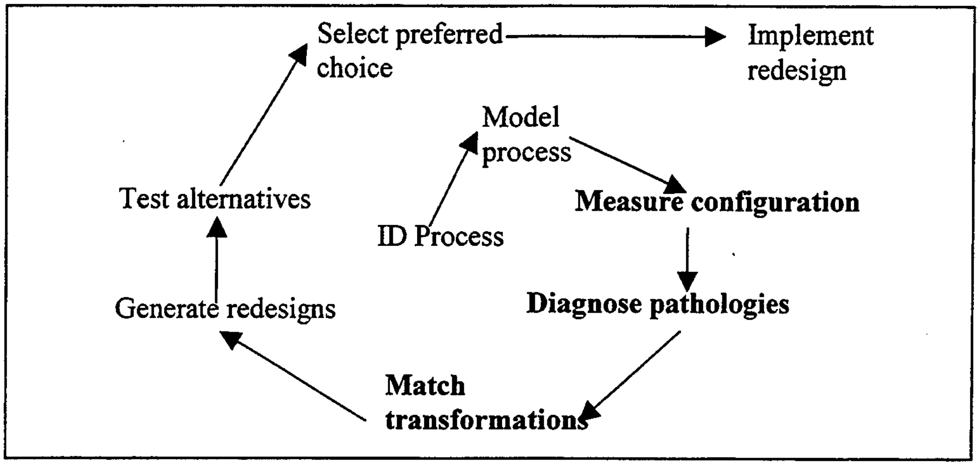

Figure 3. KOPeR Redesign Methodology (From Nissen 1998).

The evolutionary or spiral flow represents a blend of expert reengineering methodologies (e.g. Davenport 1993, and Hammer and Champy 1993). KOPeR is employed for steps 3–5 to automate process measurement, pathology diagnoses, and transformation matching.

Using this KBS can significantly speed up the time spent during process analysis and redesign. KOPeR requires the user to input process attributes as shown in Table 4. This KBS employs expert system technology to automatically diagnose process shortcomings and provide recommendations that can generate significant performance improvements. Before a recommendation is made the redesign alternatives are compared against the process baseline to evaluate their performance. The KOPeR method suggests simulation of alternatives before committing time and money toward a problematic implementation.

Attribute	Definition
Process Length	Number of nodes in longest path
Process Breadth	Number of distinct paths
Process Depth	Number of process levels
Process Size	Number of nodes in process model
Process Feedback	Number of cycles in graph
Parallelism	Process size divided by Length
IT Support	Number of IT-support attributes
IT Communication	Number of IT-communication attributes
IT Automation	Number of IT-automation attributes
Organizational Roles	Number of unique agent role attributes
Process Handoffs	Number of inter-role edges
Organizations	Number of unique agent organization attributes
Value Chains	Number of unique activity value chain attributes

Table 4. KOPeR Process Inputs

Key measurements are assigned values by KOPeR that represent the level that a particular measurement was found to contain. These measures are summarized below.

Measures	Definition and Value Ranges
Parallelism	The degree to which a process follows a sequential path. 1.0 (Sequential process) - Greater than 1 (Parallel process)
Handoffs fraction	The level of process fragmentation produced by handing off work to another person. 0.0 (None) -1.0 (Fragmented)
Feedback fraction	The level of rework produced when checking is used to ensure quality. 0.0 (No friction) -1.0 (High friction)
IT Support	The level of IT available to support the process such as computers systems. 0.0 (Inadequate) – 1.0 (High)
IT Communication	The level of IT communications available such as email, voice, shared databases/networks. 0.0 (Inadequate) – 1.0 (High)
IT Automation	The level of IT available to automate the process such as expert systems and intelligent agents. 0.0 (Inadequate) – 1.0 (High)

Table 5. Definitions of KOPeR Measures and Pathologies

From these measures KOPeR makes recommendations for redesign. Such recommendations may be to employ more information technology or to reduce the number of handoffs. KOPeR does have some limitations. It does not have the capability to discern whether or not a detected process pathology is acceptable. For example, a process may be identified as being "too sequential." However, the process steps involved may be mutually dependent on each other requiring a sequential flow.

I. SUMMARY

The previous discussions provide a comprehensive review of knowledge management. A particular emphasis is placed on recent research (Nissen et al. 2000) that proposes an integrated approach to knowledge management and system design. This methodology, coupled with the KOPeR analysis tool, will be used to examine the SARSAT process to identify alternatives that offer significant potential to enhance the knowledge work associated with responding to SARSAT alerts. The goal is to identify organizational and technological interventions that can improve decision-making, knowledge retention, transfer, and sharing which, in turn, facilitate an increase in overall performance of the process.

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III. CURRENT PROCESS

A. BACKGROUND

The COSPAS-SARSAT[1] satellite system (NOAA 2000a) is designed to monitor and process emergency signals originating from an aircraft, ship, or person in trouble. The system became operational in the 1980s as a cooperative effort between the United States, Canada, France and the former Soviet Union. Over the years, membership has grown, and there are currently 33 member nations providing support to the system. COSPAS-SARSAT has been able to drastically reduce the amount of time required to locate and assist people in distress. This has resulted in many people being saved who otherwise may have died. Since becoming operational, the system has been credited for rescuing 4,000 persons in the USA and over 11,000 worldwide. COSPAS-SARSAT (Figure 4) currently consists of 11 satellites, 44 ground receiver stations called local user

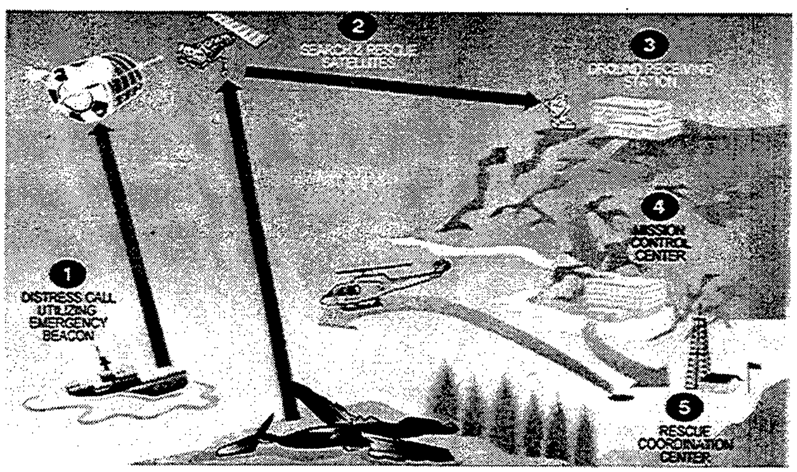

Figure 4. COSPAS-SARSAT System (From NOAA 2000).

[1] **COSPAS** - Cosmicheskaya Systyema Poiska Avariynich Sudov...translated from the Russian language this means "space system for the detection of vessels in distress."
SARSAT -Search and Rescue Satellite-Aided Tracking

terminals (LUTS), and 22 mission control centers (MCCs). Upon detection of a distress signal, the receiving satellite relays the signal to a LUT. The LUT then relays the alert to the area MCC, which in turn forwards it to the appropriate search and rescue center for action.

The system detects signals from users equipped with emergency radio beacons. There are three kinds of emergency radio beacons: 1) aircraft are installed with Emergency Locator Transmitters (ELTs), 2) ships use Emergency Position Indicating Radio Beacons (EPIRBs), and 3) Personal Locator Beacons (PLBs) are used by people taking part in remote inland activities, such as mountain climbing or canoeing. The system uses Doppler processing techniques (using the relative motion between the satellite and the beacon) to determine the user's location. The first satellite pass results in what is known as an A or B solution, meaning the user position is in one of two places. A second satellite pass is needed to resolve the ambiguity and determine the approximate beacon position.

The first generation of beacons, mostly ELTs, transmit on 121.5 MHz. These signals can be processed by the COSPAS-SARSAT system. However, the satellites are limited in their capability in relaying all 121.5 MHz signals. During a satellite pass, there must be a LUT or ground station "in view" to immediately receive the relayed signal. Since the satellite has no alert storage capability, it will experience a "missed pass" if no LUT is available. Another deficiency is that the satellites cannot differentiate between actual 121.5 Mhz alerts or a same frequency spurious signal often generated by an unknown source. As a result, there is an extremely high false alarm rate. In addition, the 121.5 alerts do not provide any owner registration information to assist search and rescue

personnel. This causes a considerable amount of time and resources to be expended investigating these signals. For these reasons, COSPAS-SARSAT authorities are planning in 2009 to phase out the processing of these 121.5 Mhz signals in favor of the newer 406Mhz beacons. This long phase-out period should provide mariners with sufficient time to make the transition.

The second generation of radio beacons developed to be more readily detected by satellites, transmit on 406 MHz. Alerts transmitted by these beacons can include vital encoded information: such as the registered owner, type of vehicle (aircraft or vessel), and country of registration. Unlike the 121.5 MHz beacons, the orbiting satellites have a capability to "store and hold" the 406 MHz alerts should a LUT not be visible at the time of receipt. The alert can then be held and relayed at a later time when a ground station is in-view. The processed signal results in a position error no greater than 1 to 3nm, which is much better compared to 12-16nm for 121.5 Mhz beacons. All these features make it much easier for search and rescue forces to respond to 406 MHz type distress signals.

The following table shows a comparison between the beacons regarding the high number of alerts received and responded to by SAR authorities in the United States.

SARSAT Alerting System

Alerts received in United States between 1996 — 2000

	Initial Alerts	Composite Alerts	Actual Distress	Lives Saved
121.5 & 243 MHz	471,358	51,713	801	288
406 MHz	12,793	4,882	999	1,281

Table 6. SARSAT Alert Statistics (From USCG 2000).

As shown above, the 121.5/243 MHz beacons have an extremely high false alarm rate. A composite alert results after a second successful satellite pass resolves the positioning ambiguity (initial alerts result in two possible locations) and identifies the correct position. Each alert is responded to by following specific procedures appropriate for the beacon type, and whether it is a new or subsequent alert for an existing case.

SARSAT alerts are sent to a Coast Guard Command Center that has jurisdiction for the location where the alert originates. Command centers are located at Coast Guard Districts throughout the United States and have an area of responsibility (AOR) spanning several states as shown in Figure 5.

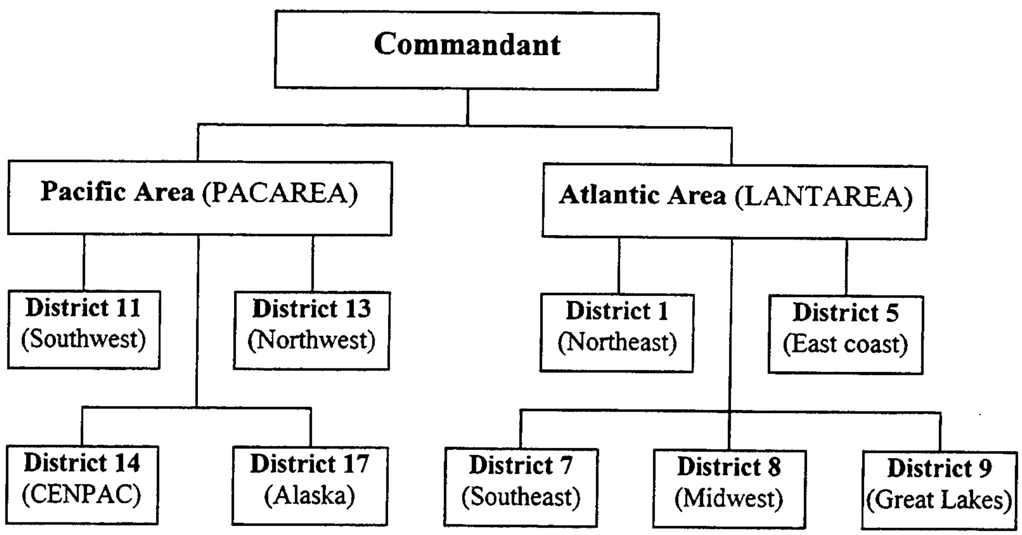

Figure 5. USCG Area/District Organizational Breakdown.

These command centers maintain 24 hour operational oversight and support for all ongoing missions (including SARSAT alerts) within their respective AOR. The Coast Guard accomplishes its missions using a myriad of assets that include cutters, boats and aircraft. The larger cutters (e.g., Medium and High Endurance) are assigned to Area units, and Districts control the patrol boats, buoy tenders, helicopters, and fixed wing aircraft.

B. PROCESS DESCRIPTION

Responding to SARSAT alerts follows seven major steps, each containing specific tasks. These process steps are summarized below:

1. Receive the Alert
2. Analyze the Alert
3. Search and Rescue Mission Coordinator (SMC) Decision
4. Alert Decision
5. Deploy Asset
6. Response Decision
7. Case Documentation

This seven step process is summarized in Figure 6. Below each step is a list of attributes to identify the following process elements:

1. Activity name.
2. Role of the agent responsible for its performance.
3. Organizational affiliation of the agent.
4. Technology employed for process support, communications, and automation.

The attributed graph contains the basic information that will be used later during process analysis.

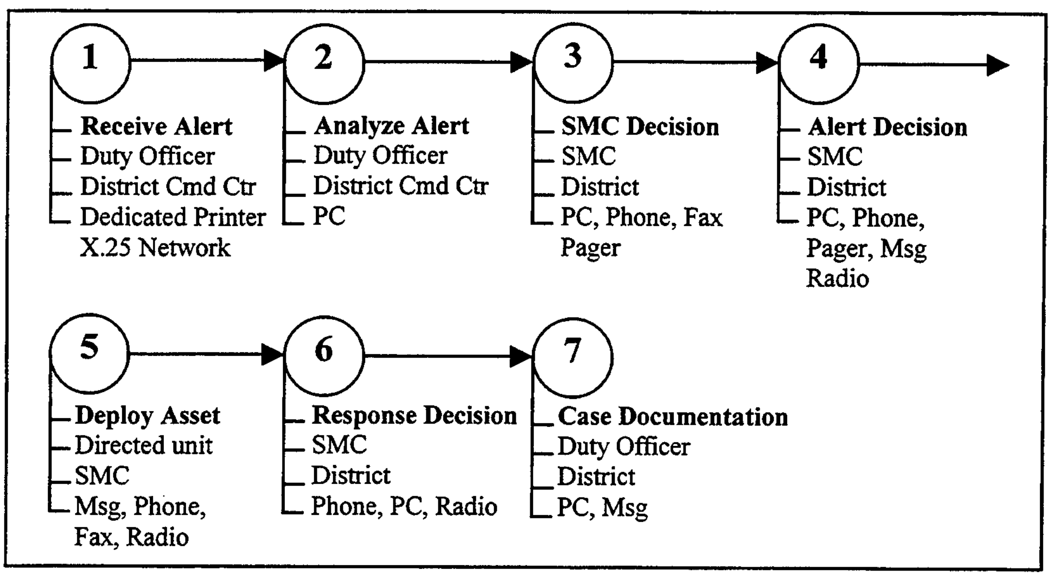

Figure 6. Process of Responding to SARSAT Alerts.

The Coast Guard responds to thousands of SARSAT alerts each year. They are each aggressively pursued in accordance with USCG policies to ensure a rapid and

effective response. The procedures to which command centers adhere have evolved from experience and lessons learned. Responding appropriately to SARSAT alerts is crucial since a mariner could be in distress and in need of assistance. The following details the process of responding to SARSAT alerts:

1. Receiving an Alert

Alerts are processed and relayed by U.S. Mission Control Center (USMCC) located in Suitland, Maryland, to the appropriate Coast Guard District Command Center. Relaying an alert is an automated process. The USMCC computers generate an alert message and transmit it over a dedicated communication line to the receiving command center. Incoming alerts are immediately routed to a dedicated printer for retrieval. The command duty officer (CDO) is notified of an alert arrival and will then assign it to a duty officer for further analysis. The work flow and the associated attributes for this stage is shown in following Figure 7.

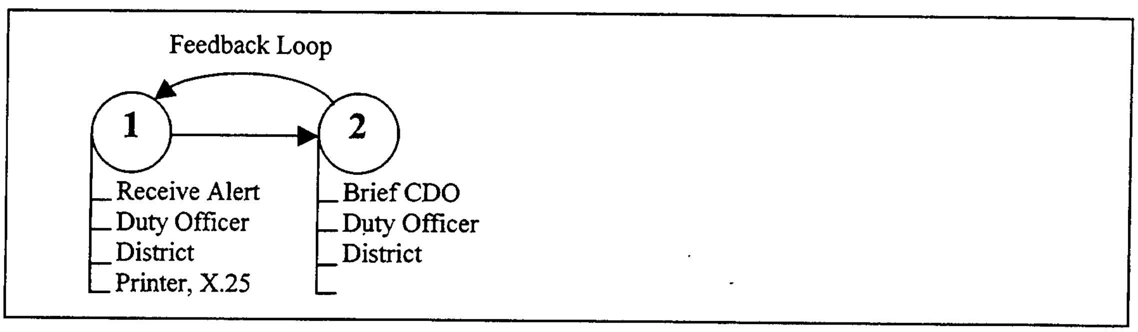

Figure 7. Receiving SARSAT Alert.

2. Analyze the Alert

The incoming alert is immediately analyzed after its receipt. A duty officer will be looking to determine the type of alert, whether it is a new or subsequent alert generated by another satellite pass, and where it plots geographically. Plotting the latitude and longitude is done using specialized search planning software. The CDO may

assist in the analysis or will confirm the findings identified by an assistant duty officer. Identifying the precise geographical position is crucial as it will be a primary factor for decision-making in the next step. This process activity is depicted in the Figure 8.

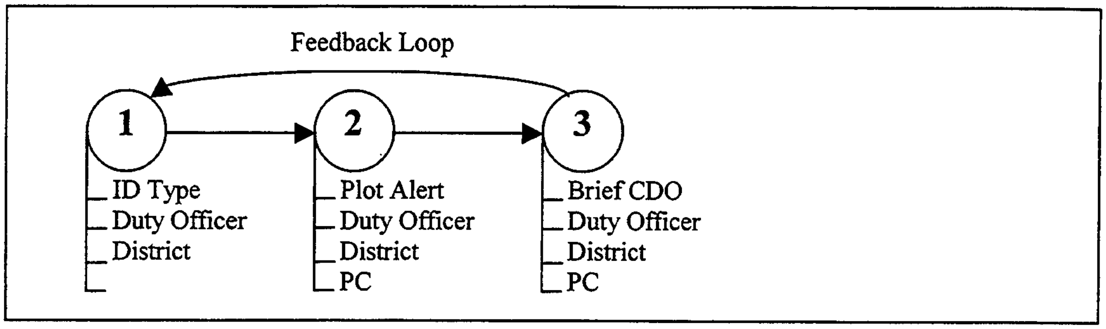

Figure 8. Analyzing SARSAT Alert.

3. SMC Decision

Identifying who will be the SAR Mission Coordinator (SMC) is an important first step at this stage. Officially, the SMC is the designation referring to the responsible party who will oversee and coordinate the case. This is normally the department head for the District Office of Search and Rescue (OSR). By default, the District automatically assumes the SMC by just receiving the alert. Handing-off the SMC to a district unit (such as a Group) may be permitted if the receiving unit is in closer proximity to the incident and has the resource capability in terms of people, equipment, training and experience. At this time, Coast Guard Districts within the Atlantic Area have a policy to maintain SMC at the District level. The SAR procedures for the Pacific Area allow for some flexibility. For example, District 11 immediately transfers SMC to a Group unit for SARSAT alerts plotting within their respective area of responsibility. When passing the SMC, the District will fax the alert to the Group Operations Center. The commanding officer of the unit will assume SMC and provide an appropriate response. This SMC exchange will be followed by a telephone call to confirm fax receipt and ensure a positive

handoff. Subsequent alerts for this case will be relayed by the District Command Center using this fax/phone procedure. District OSR is briefed regularly on the actions taken. This may be done in person, by phone or pager. A summary of this step is shown in Figure 9.

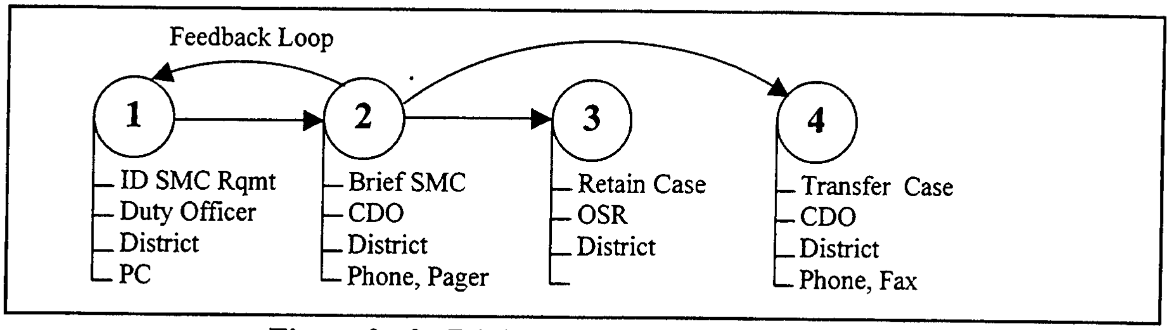

Figure 9. SAR Mission Coordinator Decision.

4. Alert Decision

After analysis is complete, a decision is made on what action must be done. The unit assuming SMC will immediately issue an Urgent Marine Information Broadcast (UMIB) on VHF marine radio band channel 16. This local broadcast notifies nearby mariners of the beacon activation and its approximate location, and also requests those able to render assistance. Concurrently, a decision is being formulated in accordance with Coast Guard procedures. Duty officers will refer to the appropriate "Quick Reference Sheets" (QRS), which are 1 to 3 pages in length and provide guidance on quickly identifying actions that must be taken. Many factors such as weather, distance offshore, availability and suitability of a particular asset are considered. Generally, helicopters (H60 or H65) are used to respond to alerts plotting within 100 miles. A C130 fixed wing aircraft is used for long range cases and to provide a helicopter safety escort for missions exceeding 60 miles offshore. Underway surface assets such as a patrol boat may be diverted if they can provide a quick response. The smaller boats (e.g. 41 foot

utility boat) normally investigate alerts plotting within harbors and close to shore. All actions taken are with SMC approval. This activity is summarized below in Figure 10.

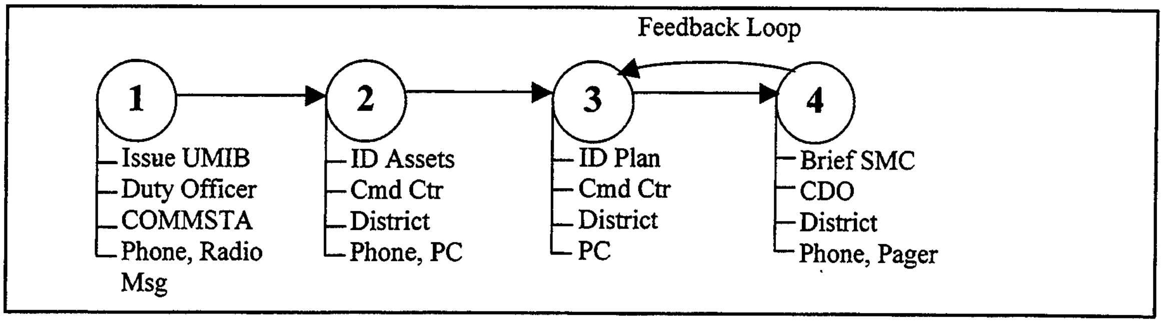

Figure 10. Alert Decision.

5. Deploy Asset

The SMC of the case will provide a general Search Action Plan (SAP) and will direct an air or surface asset to proceed directly to the position provided in the latest alert message. While en route to the alert position the crew will attempt to "home" in on the beacon by using directional finding (DF) equipment. The DF signal is instrumental since there can be significant error between the alert message and the actual beacon position. Should a mariner be located in distress, the SMC will be contacted via radio and a decision will be made on how best to provide assistance. If no distress indication is found at datum, the initial SAP will be implemented to search the general area to confirm no distress situation exists. These steps are shown in Figure 11.

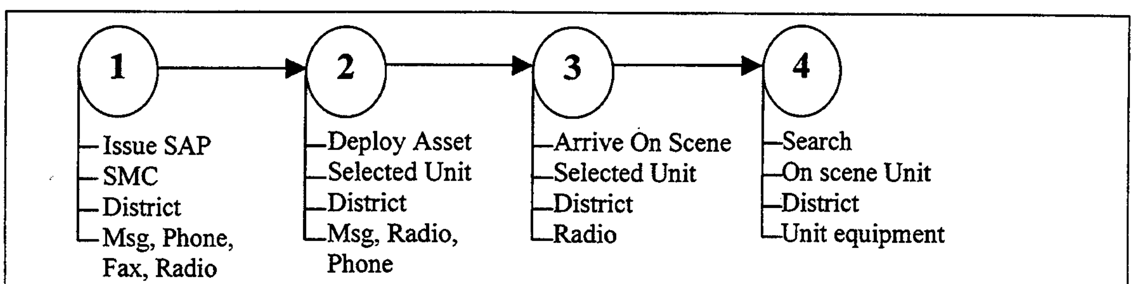

Figure 11. Deploy Asset.

6. Response Decision

A response decision will be made based on feedback provided by the on scene unit. The on scene unit provides vital input to the SMC recommending how the case should be executed and what assistance can be provided. Factors such as on scene weather and remaining fuel (major aircraft consideration) are provided by the Aircraft Commander (AC) or the Office In Charge/Commanding Officer (OIC/CO) of a cutter.

At this point, the alert may be classified as an actual distress, in no imminent danger, a false alarm, or unlocated. The SMC will make a decision based on the severity of the situation. That may include removing persons from a sinking vessel, medical evacuation (MEDEVAC) of an injured or ill person, providing dewatering pumps, or assisting in towing a disabled vessel where no commercial assistance is readily available. For the other situations, units will be directed to locate and quickly secure those beacons that have been accidentally activated. This is necessary because these beacons continue to radiate a DF signal, which could interfere in locating another beacon where an actual emergency may exist. These steps are summarized in Figure 12.

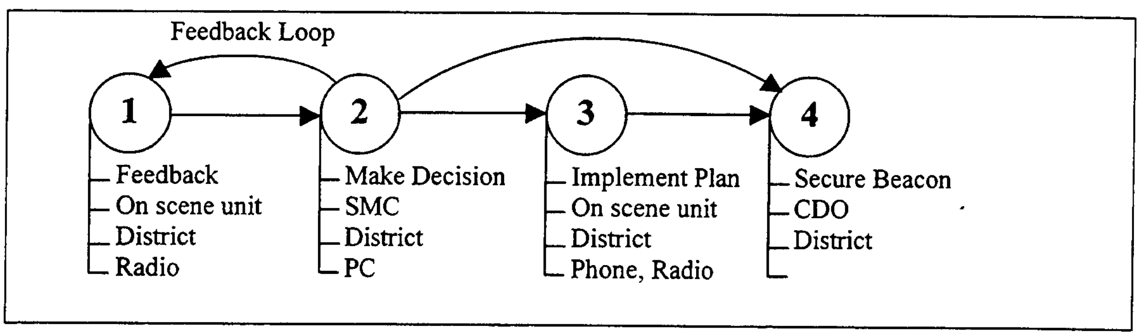

Figure 12. Response Decision.

7. Case Documentation

Coast Guard procedures require the SMC to maintain a chronological (CHRONO) record during the entire case. These logs serve as a working document to record actions

and decisions taken during the case. Afterwards, a CHRONO is used to type a Situation Report (SITREP) that summarizes the entire case. After SMC review, these documents become part of the official case file and the report is sent to the parent organization. These steps are summarized in Figure 13.

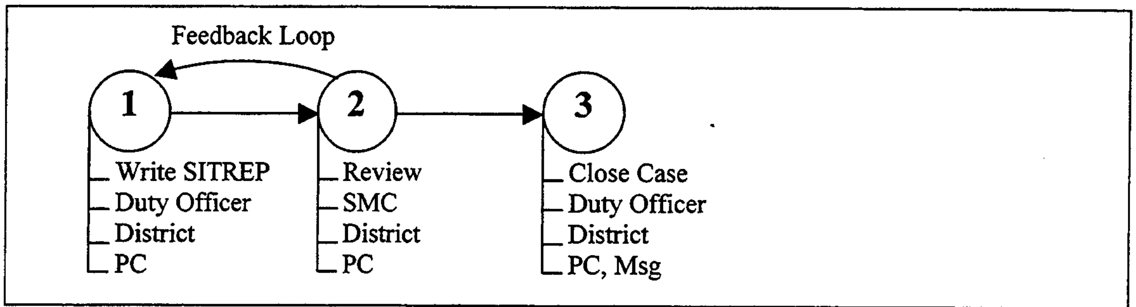

Figure 13. Case Documentation.

8. Process Summary

The command center duty officers work as a team to formulate a response in accordance with the SMC and established Coast Guard procedures. This facilitates the movement of a surface or air asset within minutes after receipt of an alert. The geographic position of the alert determines how quickly the Coast Guard responds. Helicopters are usually used since they provide a rapid response and can arrive on scene for local area alerts in as quickly as 30 minutes after alert receipt. Response time for alerts plotting in remote areas take longer due to lengthy transit times. On average, most alerts are resolved within 2 hours.

The process outlined shows how one alert is processed. It normally requires *multiple* alerts to resolve a case. 121.5/243 Mhz beacon alerts can take 3 satellite passes, or more, and a considerable amount of analysis before they are resolved. This is due to the inherent error in approximating beacon locations and other frequency interference. For such cases, a mariner is not normally found in distress. A responding unit has

already searched the alert positions and has often tracked the signal to a harbor or inland to a local airport where a shore team is used to locate the beacon. 406 Mhz beacons have much greater positioning accuracy and can often be located by the second *complete* satellite pass. It is not uncommon for a Coast Guard District to be concurrently SMC for 3 or more distinct alerts within their area of responsibility.

C. AUTOMATED PROCESS ANALYSIS

The SARSAT process is analyzed using a knowledge based system (KBS) that performs measurement-driven inference (Nissen 1998). This KBS tool (called KOPeR) automates the key intellectual activities required for process redesign: process measurement, pathology diagnosis, and transformation matching. The motivation for using this tool is that it provides an objective examination to identify transformations that can improve the process. Compared to manual analysis methods, it can be a more effective approach that yields results in a fraction of the time.

Process analysis on the SARSAT alert process is done using KOPeR-Lite. The lite version represents a re-implementation of core KOPeR functionality for the PC environment and is accessible through a web-based interface. KOPeR-Lite contains a limited portion of the domain-independent knowledge originally formalized in KOPeR. But, it still effectively demonstrates measurement-driven inference for process analysis and redesign. SARSAT process measurements, values, diagnoses, and recommendations are summarized in Table 7.

The first pathology identified involves parallelism with a value of 1.0. This indicates that the process may be hindered from steps being completed in a sequential manner. Redesigning the steps to combine or complete activities in parallel would be a

Measurements	Value	Diagnosis	Recommendations
Parallelism	1.000	Sequential Process	Delinearize
Handoffs fraction	0.130	Ok	None
Feedback fraction	0.261	Checking Complexity	Job empowerment
IT Support	0.391	Manual	Increase
IT Communication	0.435	Paper-based	Increase
IT Automation	0.043	Labor Intensive.	Increase. Requires substantial IT infrastructure (support/comms)

Table 7. Diagnostic Measures for SARSAT Alert Process

normal remedy. However, the tasks with the SARSAT process are mutually dependent on each other, and one cannot be readily started before the preceding is complete. For example, analyzing an incoming alert message must be completed before a response can be formulated.

The next process pathology concerns handoffs fraction or the amount of inter-agent workflow involved in completing the process. The score for this measure can range from zero (no handoffs) to one, indicating process fragmentation. KOPeR assigned a measured value of 0.13, which is considered acceptable.

Feedback fraction is measured at 0.261 indicating a need to reduce the amount of checking. KOPeR recommends that individuals be empowered to make more decisions. Military organizations suffer from this problem due the nature of their missions, organizational structure, and tradition. To mitigate the checking issue, command centers should maximize their efforts to establish "briefing thresholds" clarifying specifically what must be briefed to the chain of command before proceeding. These decisions could then be made internally by the command center. Another method to reduce feedback is to immediately pass SMC to a Coast Guard Group for SARSAT alerts occurring within

their area of responsibility (AOR). Having the SMC at the group level reduces the feedback friction caused when units need to constantly relay/brief actions to their District Command Center.

The final three measures are associated with the level of information technology employed during the process. The first measure identifies IT for support as inadequate (0.391). This is due to the nature of the workflow being a knowledge-intensive manual process. Next, IT for communications is also measured as being inadequate (.0435). Of particular note is that IT is not generally used throughout the process for case documentation, but instead, forms are filled out manually. The final measure is the level of IT used for automation (0.043). KOPeR diagnoses the process as being labor intensive and recommends additional IT systems. Automating the SARSAT alerts to be displayed upon receipt would be a significant measure to free the worker from manually plotting. Other search planning systems (called AMS and CASP) are available that automate some individual tasks, but they are infrequently used in the process since most search and rescue cases don't require extensive searches. Additionally, command centers have the AMVER database system which tracks commercial ship voyages and can be called as a responding resource to assist in long-range or remote alerts.

D. PROCESS ANALYSIS SUMMARY

The KOPeR redesign agent is used to measure the process, identify shortcomings, and make recommendations. KOPeR suggested 5 transformations to improve the SARSAT process. Transformations the can be incorporated into the process include job empowerment and increasing the amount of information technology. Although IT is already employed, expanding the use of technology can increase the speed in performing

a task, reduce potential for human error and aid decision-makers in formulating an alert response plan.

This chapter provides an in-depth examination of the SARSAT alert response process. The seven steps within the SARSAT process are first discussed individually and then the entire process is evaluated using the KOPeR KBS. This completes the first step of integrated framework discussed in Chapter Two. The next chapter examines the knowledge required to perform the SARSAT process, how it is managed, and the contextual issues associated with the process.

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IV. KNOWLEDGE AND CONTEXTUAL ANALYSIS

A. KNOWLEDGE MANAGEMENT ANALYSIS

Looking at processes in the knowledge management (KM) context consists of extending the horizontal process with vertical processes that influence performance through time and across different command center watch teams. These vertical processes (Figure 14) are obtained by examining the enterprise process from a macro perspective to identify key knowledge contributing sources. By examining the supporting processes, effective methods to distribute and retain knowledge can be identified to aid decision makers in accomplishing their work.

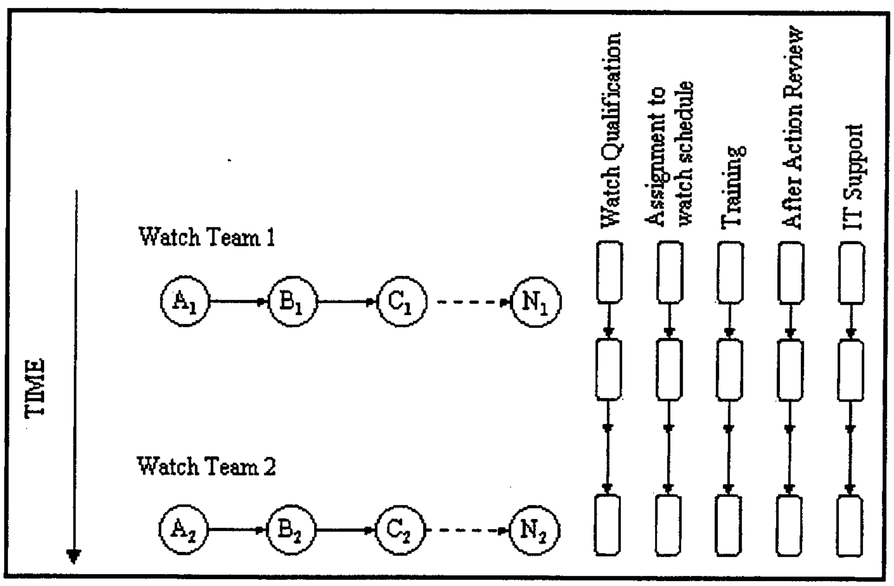

Figure 14. SARSAT Alert Vertical Processes.

The figure shows the cross-process flow for two instantiations of the main process. Activities within an instantiated horizontal process are depicted as lettered nodes. The first instantiation shows Watch Team 1 performing each of the process activities at some point of time. Later, another instantiation occurs with Watch Team 2 performing the same process activities. Using the Dixon framework, this would be

classified as a serial transfer of knowledge between the two watch teams. The focus here is on the consistency and efficacy across the process instantiations. While the horizontal process focuses on performance of the work itself, the proficiency of the vertical cross-process flows dramatically influences the process of knowledge management.

A description and analysis of the vertical-flow processes appears below:

1. Watch Qualification
2. Assignment to a Watch Schedule
3. Training
4. After Action Reviews
5. Information Technology Support

1. Watch Qualification

Personnel go through a rigorous training program before they are designated as a Command Center Duty Officer. Each command center has tailored a specific training program, but they are similar in nature. Generally, it is a four-phase program, which averages approximately 3 months to complete and has a heavy emphasis on search and rescue. The first phase involves independent study to become familiar with USCG policies, procedures, local geographical area and outlying units (e.g. groups, stations, cutters and aircraft). The second phase involves the trainee augmenting a watch team to perform on the job training (OJT). A trainee at this point is under constant supervision. The OJT provides the opportunity to interact with experienced duty officers to garner the rich tacit knowledge they possess. During phase three, the amount of oversight is significantly scaled back. This creates the most realistic environment for the trainee to further develop and gain experience. Phase four is the final point where qualification is sought. This is attempted after all training tasks have been completed and requires

successfully passing a written and/or oral test. In addition, the trainee must complete a three-week course in Maritime Search and Rescue Planning.

2. Assignment to a Watch.

Each command center has a set number of duty officers assigned to a watch. This assignment is driven by many factors, such as historical case load. For example, District 11 has three people assigned to each watch, consisting of two Assistant Duty Officers (ADO) and a Command Duty Officer (CDO).

Upon reporting for work, a shift relief process is initiated to facilitate a seamless changeover of personnel. Generally, the on-coming officer will perform the following:

1. Read the current operations brief to gain familiarity with what happened the prior day. This is important because there are usually cases or issues that carry over from the previous day and can influence current operations.
2. Review the status of district surface and air assets noting those that are deployed, scheduled to conduct patrols, and any maintenance issues that could effect asset availability.
3. Read the watch "pass-down" log. It often contains unique time-sensitive information that affects current or future operations.
4. Read through all of the active case chronological logs and incident sheets. This is necessary to obtain a firm understanding of the current cases.

After doing these things, the off-going duty officer will then verbally brief the on-coming officer about the cases currently active and any other important issues. The on-coming officer will assume the watch after acknowledging understanding of the current operational situation. A watch relief can be done in as quickly as twenty minutes, or may take up to an hour, depending on that day's case load.

3. Training

Each command center designates a training coordinator. Lessons learned or best practices identified during a case are promulgated via email, face-to-face, memos, procedure updates, or at all-hands meetings. Formal training usually focuses on search

and rescue, since it has the highest case load of all Coast Guard missions. The focus of the training is usually the decision support tools (AMS and CASP) that assist in search planning. These tools are used infrequently, because most SAR occurs close to shore, which usually does not require extensive searches. On average, duty officers may only use the specialized SAR tools a few times a year. To maintain proficiency, the training coordinator will periodically develop training scenarios for the staff to perform. Another approach that has been implemented recently involves SAR school instructors making periodic visits to command centers to test SAR planning proficiency.

4. After Action Reviews

Post action reviews can take a few different forms. For example, each morning the command duty officer conducts an operations brief for the chain of command to summarize what happened, who responded, and the outcome for all cases occurring the preceding day. These briefings often generate discussions leading to immediate feedback. For significant cases (e.g., 1996 TWA 800 airline crash), formal AARs are written and promulgated to each district command center. On a Coast Guard wide basis, the service recently implemented an intranet-based system called the Coast Guard Standard After Action Information and Lessons Learned System (CG-SAILS). The goal of the program is to provide a single, standard means for submitting after action, lessons learned, and best practices. Users have the ability to query the system via a web browser to read available reports.

5. Information Technology Support

The Coast Guard recently completed a service-wide migration to a Windows NT based computer system. Each desktop PC offers the user the standard Office suite of applications (e.g., word-processing, spreadsheet etc.). A centralized IT staff supports the

district staff offices, including the command center. Some command centers may have someone with an IT background who has developed "home-grown" systems to assist in command center work processes. For example, District 11 developed a command center intranet that functions as groupware. It provides a centralized location for files, documents, procedures and information. District 5 developed an Access database (called SMART) to track unit asset readiness. Using SMART, units electronically update their listing instead of sending in a status report. These custom solutions require specialized knowledge in their development and can be difficult to support by the local IT staff. Additionally, there may unknowingly be duplication of efforts among the command centers in attempting to solve similar problems.

B. KNOWLEDGE ANALYSIS

The purpose of this step is to identify knowledge that contributes to sustained high performance of the horizontal process activities. Knowledge analysis begins by first identifying the factors that are critical in successfully responding to SARSAT alerts. This step can only be completed after the mission and goal of the organization is fully understood. The following list of Critical Success Factors (CSFs) is determined by analyzing the horizontal process work flow:

1. To quickly and effectively analyze the incoming alert.
2. To formulate a response plan in accordance with Coast Guard procedures.
3. To provide appropriate assistance and minimize risk to personnel.

Of particular interest are the activities that contribute significantly to the performance of the main process:

1. Analyze Alert (node 2).
2. Alert Decision (node 4).
3. Response Decision (node 6).

Achieving success in each of these CSFs and in the overall process is determined primarily by the actions taken in the nodes mentioned above. These tasks require a high degree of training, experience, and knowledge that contribute significantly to the success of the process and highlight their significance in terms of knowledge management. The knowledge required for the primary knowledge activities, and how that knowledge is acquired, is discussed in the following paragraphs.

1. Analyze Alert

Incoming alerts are received via a dedicated communication line and are immediately printed on a stand-alone printer. The alert may be one of thirteen "subject indicator type" messages, which are based on whether the originating beacon is a 121.5, 243 or 406 Mhz beacon. Alerts are received after a satellite completes a pass over a particular geographic region. These alerts contain a wealth of information, particularly the "406" alerts, which can include owner registration information. Each command center has a reference manual (NOAA 1999), that describes the content for each alert message. Proficiency in analyzing these alerts is gained primarily from OJT. Table 8 outlines the knowledge required to perform this activity.

Knowledge Required	How Knowledge is Acquired
Competency of SARSAT Alert Messages	• Alert Reference Manual • Maritime SAR School • On-the-Job Training
Alert Geographic Location	• Command and Control PC • On-the-Job Training

Table 8. Knowledge Analysis of Analyzing Alerts.

Identifying where a specific alert occurs, or "plots," is critical during this step and is the basis for subsequent process tasks. Specialized plotting software is available on a command and control PC (C2PC) to manually perform this task. The 121.5/243 Mhz

beacon alerts make up a significant portion of all alerts received and often require careful analysis coupled with on-scene unit feedback to locate their specific position. In addition to the current alert position, duty officers will maintain a history of plots for all prior active alerts, which may collectively provide insights on those hard-to-locate beacons. Automating the plotting process would be very beneficial to managing the active alerts and conducting analysis.

Additionally, the SARSAT consortium reports the system will cease processing of the 1.21.5/243 Mhz beacon signals in 2009, requiring users to transition to the "406" type beacons. These beacons offer superior capabilities (e.g., positioning) compared to the older technology beacons and can dramatically reduce efforts used to locate mariners. Employing public outreach programs to promote "406" beacons would help facilitate this transition and would possibly reduce the number of "121.5" false alerts.

2. Alert Decision

The knowledge required (see Table 9) to make a decision for responding to SARSAT alerts can be very complex and must be formulated quickly. The Coast Guard has very specific procedures that govern the response. A key job aid is the Command Center Quick Reference Sheets (QRSs) that summarize applicable CG procedures and specify what type of response is required. QRSs are available for use online and/or in hardcopy form. The alert position will be the basis to identify which asset will respond. Identifying an appropriate resource (surface or area) necessitates knowing where all the assets are home ported, or stationed. Asset status sheets are updated frequently to track the assets both underway and at home station. This is a labor intensive task, since resource status changes frequently due to mechanical problems or other issues.

Knowledge Required	How Knowledge is Acquired
SAR Response Procedures	• Area/District Procedures • Maritime SAR School • OJT, QRS
Alert Geographic Location	• Analyze Alert activity
Available Resources (underway and at home station)	• OJT, Status files, C2PC, Radio communications, AMVER
Search Planning	• SAR Manual • Area/District Procedures • Maritime SAR School • QRS, OJT
Resource Capabilities	• OJT, QRS, SAR Manual
Weather	• NOAA and USN
Risk Assessment	• OJT
Situational Awareness	• OJT

Table 9. Knowledge Analysis for Alert Decision.

Other potential resources are underway assets that may be conducting a routine patrol or involved in a training mission. Usually, command centers must first establish radio communications (via another unit) to query unit(s) and decide if their current position can facilitate a rapid response. However, this step is not necessary for the larger cutters, that have the unique capability to provide real-time positioning information sent automatically to the command centers. A valuable weather resource is the National Data Buoy Center website (NOAA 2000b) that provides real-time wind and seas information from coastal buoys positioned around the country. Weather is a very important factor, since it directly effects search area plans and crew risk. For occasional long-range remote alerts, the Automated Mutual-assistance Vessel Rescue (AMVER) system is an invaluable resource to identify commercial vessels on transoceanic voyages that may be called upon to divert course and assist in investigating SARSAT alerts.

All these information inputs are reviewed, and the likely response will be for a helicopter or fixed-wing aircraft to be launched immediately. In addition, an Urgent

Marine Information Broadcast will be issued to notify mariners in the area of the situation. The responding unit at this point will be tasked by SMC to attempt to "home" in on the beacon signal using directional finding equipment as they approach the alert position.

3. Response Decision

This activity is similar to the alert decision node. The difference is that the initial alert response identified a suitable asset to be deployed to *investigate* the alert position. At that point, not much is known concerning the nature of the alert. If the beacon was a "406" type, registration information can be referenced to identify the vessel type. The SMC will now be relying on the responding unit or on-scene commander (OSC) to provide feedback to gain an understanding of the current situation. Table 10 summarizes the knowledge required for this phase of the alert.

Knowledge Required	**How Knowledge is Acquired**
SAR Response Procedures	• Area/District Procedures • Maritime SAR School • OJT, QRS
On Scene Situation	• On Scene Commander
Available Resources (underway and at home station)	• OJT, Status files, C2PC, Radio communications, AMVER
Search Planning	• SAR Manual • Area/District Procedures • Maritime SAR School • QRS, OJT
Resource Capabilities	• OJT, QRS, SAR Manual
Weather	• OSC, NOAA, NDBC
Risk Assessment	• OSC, OJT
Situational Awareness	• OSC, OJT

Table 10. Knowledge Analysis for Response Decision.

The situation may range from a vessel in distress to nothing found. For those cases where immediate Coast Guard assistance is required, the SMC evaluates the

feedback provided by the OSC and identifies what can be provided. The SMC will also evaluate if additional resources are needed. Duty officers rely on OSC feedback and Coast Guard policies and experience in making appropriate recommendations to the SMC, who makes the final decision. Weather, distance offshore, and asset capabilities are key considerations in what further action will be taken. Occasionally, SARSAT alerts require extended searches, such as when debris may have been located at the alert position. The SMC would then need to provide a search action plan of where the on-scene asset should search. If a non-distress situation is identified, the Coast Guard must look carefully at the entire situation and either provide assistance or make the opportunity for assistance available from a commercial source.

If no signal or distress situation is found, then the standard first response action is to conduct a 6 nautical mile search around the alert position (USCG 1996).

C. CONTEXUAL ANALYSIS

Coast Guard Command Centers are unique organizations in that they serve as the apex for ongoing operations. Nine command centers are used to oversee and support multi-mission operations throughout the Coast Guard. Looking at the horizontal process from a contextual perspective helps identify factors that affect the implementation or development of knowledge management systems. The following discussion describes the organization and the nature of the underlying task within the horizontal process.

1. The Role of Organizational Memory

Command centers rely on organizational memory for maintaining continuity in performing its mission. The memory is preserved through formal and informal means. Most of the retention is through formal recordings to include Coast Guard instructions, procedures, quick reference sheets (QRS) and case files. Informal means include email,

water cooler discussions, and daily pass-down logs. One significant issue affecting the command center memory is the high yearly turnover rate (30% or more) that military organizations experience.

Each case in which a command center takes part is unique. Attempts are made locally to capture the tacit knowledge gained from these experiences by conducting all-hands meetings, promulgating lessons learned, email communications, and annotating the quick reference sheets. However, not all tacit knowledge can be explicitly codified and is thereby lost during personnel transfers.

2. Structure of the Organization

A command center follows a military chain of command that requires senior officers to be briefed regularly. The organizational structure is shown in Figure 15.

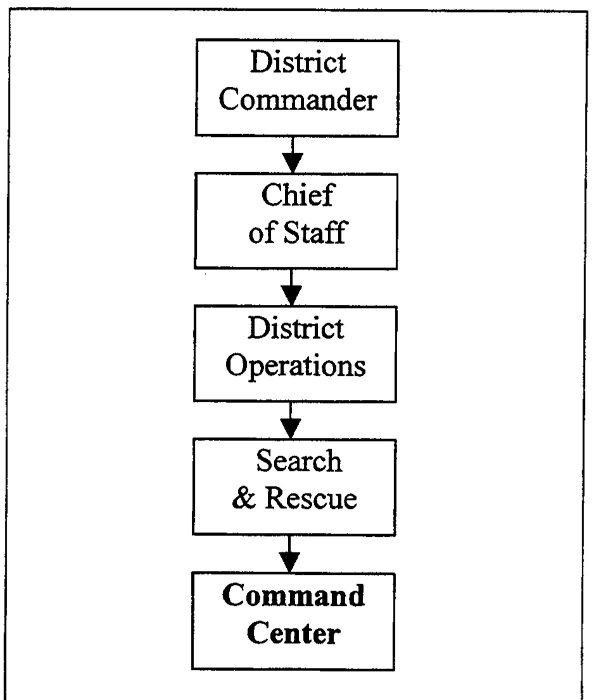

Figure 15. Organizational Structure.

A command center's primary function is to oversee and support ongoing operations within its respective area of responsibility. It is a 24 hour, 7 day a week

process that is closely monitored by the entire chain of command. The command center reports directly to the department head for the Office of Search and Rescue (OSR). This individual is regularly briefed about ongoing operations by phone, face-to-face, pager or cell phone. The chief of the command center is headed by a Lieutenant Commander and the watch team usually consists of one officer and two enlisted personnel. The senior watch member is the Command Duty Officer (CDO) and serves as a supervisor and liaison to the chain of command. Personnel selected for command center duty are closely screened to ensure they possess a suitable operational background, have outstanding performance appraisals, and excellent communication skills. This means that a person would not normally be assigned to a command center until at least his/her third job assignment. The CDOs have usually completed two "afloat" tours, before being assigned to the command center as a Lieutenant Junior Grade or Lieutenant. The Assistant Duty Officers (ADOs) tend to be First or Second Class Petty Officers selected from the Quartermaster Rate (ship navigators). Quartermasters are selected because their specialty often provides the operational experience conducive to working in a command center.

3. Organizational Incentives

Organizational incentives for high performance have been established primarily through formal means. These incentives are usually military awards for superior performance. However, an award also becomes an entry in a member's permanent record and can become a factor in promotion and obtaining a desired future job assignment.

4. Nature of the Underlying Task

Search and Rescue accounts for a considerable percentage of the time a command center spends compared to the other mission areas. The nature of the SAR mission is a prime motivator because duty officers know their actions can directly influence the

outcome of assisting a mariner in distress. Duty officers are therefore vigilant to identify new procedures and methods, and pass tacit knowledge to their peers. This knowledge can become a significant contributor in solving a unique or difficult SAR case. Each command center case must be handled in an extremely effective and efficient manner. Some days can be uneventful and others can be nearly overwhelming in terms of case load. Coast Guard procedures for each mission area (e.g. Search and Rescue, Law Enforcement) have been condensed into Quick Reference Sheets (QRSs) that serve as a primary job aid in providing specific guidance on what must be done. The QRSs are cross-referenced so that they direct a user to another sheet if a task borders across similar processes. QRSs are evolving documents that are updated frequently to incorporate knowledge and maintain their prominence as a duty officer's first reference for guidance in completing command center tasks.

D. SUMMARY

The preceding discussions examine the SARSAT process from a knowledge and contextual perspective. These analyses are the second and third pillars of the integrated framework discussed in Chapter Two and directly contribute to the main process analysis performed in Chapter Three.

The preceding analysis discusses how responding to SARSAT alerts is a knowledge intensive process requiring a high degree of training and prior operational experience. The knowledge analysis (as did the KOPeR analysis) identified the need to employ additional information technology systems to automate some tasks in the "analyze alert" and "alert decision" nodes, in order to improve the performance of the process. A significant contextual issue that challenges the ability to maintain the

organizational memory is the yearly transfer of personnel. These scheduled job transfers are a military norm that require creative methods to counter this threat. From a knowledge management perspective, command centers have varying degrees of effectiveness in leveraging their available NT computer system to perform core SARSAT process functions (e.g., resource availability, case documentation). Alternative approaches to address these issues are discussed in the next section.

E. ALTERNATIVE APPROACHES

The results of the process analysis (from Chapter Three), coupled with the knowledge and contextual analysis (in the preceding paragraphs) are used to discuss five technological and organizational interventions that offer potential to innovate the SARSAT alert process.

1. Automating SARSAT Alert Plotting and Management

Upon arrival, SARSAT alerts are currently manually plotted using specialized geographic plotting software. If this task can be automated, it would accelerate alert analysis, ease management of all active alerts, and mitigate the potential for human error. Automating display of the latitude and longitude of a distress alert would be a significant improvement over the current method. However, some additional functionality would increase the robustness of such a system.

First, the duty officers will often be engaged in work away from the immediate area of the "alert" computer, necessitating inclusion of an audible signal to call attention to their arrival. Having the alert messages automatically printed upon arrival can serve as a backup measure to support manual chart plotting if the automated system were to experience problems.

Another feature for inclusion is an alert "status window" that provides a consolidated view of critical information associated with all active alerts. As previously mentioned, it takes two satellite passes to compute an alert position, and duty officers are particularly interested in knowing at what time the next satellite pass is scheduled to occur. Providing a status window would be very beneficial for decision-making and in managing all active alerts.

SARSAT alert information is frequently shared by a District Command Center with their outlying units (e.g., groups and air stations), who are tasked in providing a response. By leveraging the Coast Guard's intranet, Group units who assume the critical SMC role could have electronic access to the alert messages to reap the automated plotting and management benefits discussed above.

2. Command Center Groupware

The SARSAT analysis above, reveals how case documentation is being completed using manual paper-based forms. This inefficient method adversely affects both the horizontal and vertical processes by hindering concurrent access to these important "working papers." A groupware system can mitigate the concurrent access problem and allow case documentation to be stored along with other key process knowledge (e.g., QRS response procedures) as discussed in the preceding knowledge analysis.

A unified approach to designing and developing a groupware system is recommended. Standardizing locally developed efforts into a common groupware system prevents duplication of efforts, facilitates easier system administration, and allows local initiatives to be leveraged by all command centers and other units (e.g., Group Operation

Centers) that perform similar type functions. One key consideration of this groupware system is the need to incorporate suitable backup measures to maintain access to critical information during system "down-times."

3. Real-Time Position Tracking of Air and Surface Resources

District Command Centers oversee current operations that cover a wide geographic region. Knowing where all currently deployed units are located is essential in formulating a response to a SARSAT alert or other mission needs. The knowledge analysis identified how current asset-monitoring methods can be inefficient in tracking the position of underway or deployed units. However, the larger Coast Guard cutters do have capabilities to provide real-time positioning information to the command centers. Resource decisions could be greatly improved, if this electronic reporting system were expanded to all Coast Guard District air and surface assets (e.g., patrol boat class and larger). The command centers would then have an up-to-date and inclusive decision support system to immediately identify underway asset(s) for use in search and rescue and/or other mission needs.

4. Command Center Staffing

In the contextual analysis, maintaining the organizational memory was found to be challenged by the military norm of transferring personnel every few years. The organizational memory base is affected as some knowledge (particularly tacit knowledge) is lost as personnel depart for their next assignment. Extending job tour lengths by offering job extensions can be an effective measure. However, demands for shore billets, job variety, and service needs can challenge efforts to adopt this alternative.

A second alternative is to select people already stationed at units that are within the same district as the command center where they will be assigned. These personnel bring with them a considerable amount of local geographic knowledge and operational experience of key Coast Guard missions within that particular district. For example, District 7 (covering the Florida area) has a heavy drug interdiction and illegal immigration case load. Assigning personnel from these units to the command center allows opportunity for local tacit knowledge to be maintained, shared, and leveraged in future operations. However, a wide implementation of this alternative can lead to low job availability for others desiring assignment, or to lower morale for personnel desiring to leave a particular geographic area.

A third staffing approach in maintaining the organizational memory is to maximize augmentation of the command center staff with prior service reserve members. Members leaving active duty USCG military service are well suited for this purpose, since they often possess the required operational background. Reserve personnel are favored because they typically receive less frequent job reassignments. However, the benefits provided are not realized on a day-to-day basis, because reservists normally only work one weekend a month and a two weeks a year.

5. Empowerment

The process of responding to distress alerts received through the SARSAT system was examined in Chapter Three. It was noted in the KOPeR analysis that feedback fraction (Table 7) was high, denoting the process was hindered by excessive "checking complexity." When the SAR Mission Coordinator (SMC) responsibility is held at the district level, a considerable amount of feedback occurs between the command center and

the SMC. This is due to the nature of the mission and military culture. We recommend two alternatives that offer potential to reduce the feedback fraction.

First, fully empower the command centers to make key decisions up to established thresholds. This limited delegation of responsibility can be a plausible risk considering CDOs (as discussed above in the KM analysis) are carefully selected for command center assignments and have completed a rigorous qualification program that tests their knowledge and decision-making capability. Having established thresholds provides a means to minimize outcomes if a wrong decision is made.

The second option is to delegate SMC (case ownership) from the district level to an outlying group unit. A Coast Guard Group is often better suited to oversee a SARSAT case. Groups possess a high level of local knowledge regarding their area of responsibility (AOR) and often have better radio communication capabilities to communicate directly with responding air and surface assets. Feedback fraction can be reduced when a group holds SMC, because they are not required to provide as many status reports to their District Command Center. Coast Guard District Eleven has found the "feedback fraction" to be effectively reduced by immediately delegating SMC for SARSAT alerts plotting within a Group AOR. Other Coast Guard Districts can realize these benefits if they adopt a similar policy.

V. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the purpose of the thesis, the research methodology, and conclusions drawn from analyzing the SARSAT alert process to identify performance enhancing alternatives. It concludes with recommendations and a proposed area of possible future research.

A. SUMMARY

Coast Guard Command Centers perform a myriad of processes that coincide with the service's multi-mission responsibilities. This thesis examines emergency distress alerts received through the SARSAT system, which are important due to the substantial number of alerts responded to by the Coast Guard each year. This process is representative of the typical functions command centers perform and thereby facilitates knowledge management interventions to be leveraged across other related processes.

The approach used for process analysis draws from current research developed by Nissen, Kamel, and Sengupta (2000). This methodology takes an integrated approach by focusing on process, knowledge and contextual issues associated with a process to identify requirements that facilitate designing of supporting information systems.

B. CONCLUSIONS

Overall, this research identifies five organizational and technological alternatives that offer potential to innovate the SARSAT process. These alternatives are identified by the KOPeR analysis conducted in Chapter Three and the knowledge and contextual analysis conducted in Chapter Four.

The organizational alternatives include maximizing job empowerment within command centers and outlying units (e.g., groups) to mitigate "feedback fraction" and employing unique staffing practices to alleviate the knowledge lost caused by frequent job transfers. The three technological alternatives include employing a standardized command center groupware system, electronic plotting and management of SARSAT alerts, and expanding the current real-time tracking capability to include all Coast Guard District air and surface assets.

Adopting these alternatives can lead to greater overall process performance. Particularly, in analyzing SARSAT alerts, managing information/knowledge can be improved, and making critical response decisions can be enhanced. An in depth discussion of these alternatives is provided in Chapter Four.

C. RECOMMENDATIONS

In the course of this research, two recommendations are identified that offer potential to improve the Coast Guard's response to SARSAT alerts and foster knowledge transfer among the District Command Centers: 1) public outreach, and 2) virtual discussion board. These two recommendations are discussed below:

1. Public Outreach

The first recommendation is for the Coast Guard to maximize efforts to ensure the public is aware of benefits of "406" beacons and the upcoming 2009 termination date for processing of "121.5" beacon alerts. The recent technological improvements of "406" EPRIBs make it important to promote beacons that also feature the Global Positioning System (GPS) capability. Currently, if the receiving satellite fails to obtain a sufficient *duration* of signal to perform Doppler analysis (for positioning computations), it will

result in what is commonly called a "missed pass." However, a "406" beacon having the enhanced positioning capability can still relay a GPS position through the SARSAT system. This can mitigate the "missed pass" problem and allow command centers to immediately dispatch resources to the GPS position, rather than waiting up to 50 minutes for the next satellite pass. Moreover, the error associated with GPS positions can be 100 meters or less, making it easier to locate the mariner and minimize the need for extensive searches. These GPS capable beacons cost a few hundred dollars more, but their benefits can be easily articulated to justify their purchase.

Wide adoption of these enhanced "406" beacons offers significant potential to aid duty officers during the "analyze alert" and "alert decision" nodes of the SARSAT alert process. The Coast Guard Auxiliary and Marine Safety Vessel Inspectors are two logical avenues to promote these enhanced "406" beacons to the public and private sectors of the maritime community.

2. Virtual Discussion Board

In the research, it is noted the richest source of knowledge can often be provided through informal means. The evolution of the internet and intranets has led to online discussion boards (e.g. Military.com), that create an informal environment, but in a virtual setting. This is particularly useful for participants that are separated by time and distance, such as the nine Coast Guard Command Centers located throughout the United States. Employing an online discussion board within the Coast Guard intranet would serve as a means to draw the command centers together to engage in "water-cooler" type discussions.

Expected benefits of a virtual discussion board include fostering discussions that can lead to new ideas, exchanging of lessons learned, and sharing of locally developed best practices.

D. FUTURE RESEARCH

The integrated analysis performed in this thesis demonstrates the robustness of the framework. This approach examines not only the process at large, but the knowledge and contextual issues (that other methodologies may overlook) that affect successful implementation of knowledge management innovations.

This thesis focuses on applying the integrated framework in a Search and Rescue application, but this methodology could be leveraged in other Coast Guard mission areas that also perform knowledge intensive processes. In particular, cutter training is a promising area for this approach.

Crews assigned to a Coast Guard Medium and High Endurance Cutter are required to participate in periodic proficiency training. The goal is to provide a training environment to assess the ability of the cutter to perform its missions and improve its training team skills. Crew proficiency is evaluated by expert "ship riders" who oversee drills conducted by onboard training teams (e.g., damage control, navigation and seamanship). It's the responsibility of the training teams to conduct the drills, identify problems, train crewmembers, and ensure safety during the exercises.

The training cycle is usually one or two years in length and has the following process flow: 1) pre-inspection—to assess crew strengths and weaknesses; 2) inspection/training—to perform a re-inspection of weak areas and conduct training with

subject matter experts, and 3) post-inspection—correcting remaining deficiencies and conducting routine proficiency training.

Examining the three phase training cycle using the integrated knowledge management and system design framework may identify interventions that offer potential to innovate cutter training program. This can lead to a more effective means in attaining a peak level of cutter readiness.

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